



March 31, 1981

WJM copy

Mr. A. Pauwels
Bethlehem Copper Corporation,
#2100 - 1055 W. Hastings St.,
Vancouver, B.C.
V6E 2H8

Dear Andre:

Enclosed is a summary of results from a thin section study that I made in 1976 of samples from the Fish Lake deposit. Corresponding rock samples for your reference were mailed under separate cover.

Enclosed also are several thin sections that I borrowed last month from Carl Lalonde. Regarding these samples, FL 81-1, 172.5, 193.77 and 242.8, I would not refer to two of them as quartz diorite, I suspect they are actually porphyritic volcanic rocks so andesite would be more apt. The thin section descriptions by Geotex were well done. I think the matrix of 172.5 is partly silicified and it is cut by quartz-sericite-magnetite and carbonate veins. I noticed carbonate-gypsum-epidote (or zoisite) veinlets in 193.77. Quartz-chalcopyrite-pyrite veinlets cut hematized magnetite veinlets and are cut and offset by carbonate veinlets. One carbonate veinlet has a pyrite core and a carbonate alteration halo. In 242.8 pyrite-carbonate-chalcopyrite(?) veinlets are cut by carbonate veinlets, quartz with chlorite-carbonate cores, and quartz-gypsum. The matrix has secondary quartz. If there was early biotite alteration, no evidence of it remains.

Let me know how the Fish Lake project is going and I would appreciate it if you would contact me when plans for the summer are finalized.

Please remind Carl and Al about the Victoria Invitational Golf Tournament on April 10; you and Norma should consider coming if you can.

Regards to yourself and Norma,

W.J. McMillan
Senior Geologist, Geological Division
Mineral Resources Branch

WJM/dlb

Encl.

Fish Lake

Summary of Thin Section Study

1. Hole Q73-3: The country rock is altered mafic plagioclase porphyry ... probably it was porphyritic lava originally. Magnetite-actinolite-biotite-quartz rich clumps pseudomorph mafics. Plagioclase phenocrysts are 20-40% altered to hydromica(?). Quartz occurs as crystals and clumps of crystals; much of it is probably secondary. The matrix is 50 to 80% altered to a mix of biotite, chlorite, actinolite, quartz and other components.

Pervasive biotite alteration was early; argillic-propylitic alteration was later.

2. Hole Q73-11: The country rock is variable from fine grained to porphyritic; matrix alteration varies from 40-100%; phenocrysts are variably altered (less intense deeper in the hole?).

Alteration mineralogy does not change very much with rock type. In all, early pervasive biotite alteration was overprinted by an alteration assemblage of sericite, quartz, carbonate, \pm chlorite, local hematite after magnetite and varying amounts of gypsum.

Mafic minerals alter to chlorite, iron-rich carbonate and opaque minerals.

Quartz feldspar porphyries alter to sericite, \pm kaolinite, carbonate, \pm chlorite (after mafics), \pm quartz, \pm gypsum. Evidence of early biotite alteration is lacking.

Overall, the country rock is variable from massive to porphyritic lava and is cut by QFP dikes. Pervasive biotite alteration occurs in the country rock but not in the dikes.

Thin Sections: 154 - altered, tan colored QFP; 205 - bleached out, tan colored rock - lava?; 290 - dark colored biotite altered mafic plagioclase porphyry (lava or intrusive?); 365 - gray plagioclase porphyry altered to carbonate + sericite + chlorite + quartz (lava or intrusive); 512 - biotitized massive, very fine grained rock; partly overprinted by sericite and some chlorite alteration (lava?); 585 - QFP cutting biotitized lava(?); disseminated biotite and clots of biotite-quartz-magnetite in the lava(?), sericite and carbonate alteration predominate in the QFP but there are clots of partially chloritized biotite-quartz-magnetite (these may be incorporated from the country rock); 693 - gray crowded plagioclase porphyry with minor amounts of quartz; plagioclase phenocrysts are altered to sericite and carbonate, primary mafics are altered to chlorite and iron-rich carbonate or sericite; the matrix altered to quartz, carbonate and chlorite. This rock is probably a dike, biotite altered lava is nearby; 862 - dark gray biotitized very fine grained rock (lava) that is bleached to a green color adjacent to fractures; biotite (now 80% altered to chlorite) is widely disseminated; 1196 - crowded QFP; primary biotite is 90% altered to chlorite and iron carbonate; quartz occurs as phenocrysts and clumps of crystals, some is secondary; the matrix is quartz and feldspar that is 50% altered to sericite and carbonate; Note that there are quartz veins here with pyrite and gypsum in their cores; the rock is QFP from 560.

3. Hole Q73-1: Only the upper part of the hole has biotite alteration. Biotite alteration was early and is overprinted by a mixed argillic/prophylic alteration; that is, biotite alters to sericite + carbonate \pm chlorite \pm quartz \pm hydromica. The country rock is mafic plagioclase porphyry with local quartz phenocrysts that is probably a volcanic rock. A post-mineralization dike has carbonate with lesser sericite, chlorite and clay alteration; quartz feldspar porphyry dikes are pre-mineral.

Alteration of phenocrysts increases down the hole from 50% to 100% but matrix alteration decreases from 60 to 80% to about 20% below 500 feet.

Thin Sections: 237 - plagioclase is complexly zoned, rims albitic, 30% altered to carbonate \pm chlorite \pm biotite; rare, rounded overgrown quartz phenocrysts; feldspathic matrix 70% altered to biotite, chlorite and quartz; cut by quartz chlorite biotite pyrite veins and quartz magnetite apatite veins; mafics(?) altered to masses of brown or green-brown biotite and opaques; disseminated magnetite. Note, the biotite or chlorite altered zones are irregular and could be pervasive matrix alteration zones rather than pseudomorphs; 388 - crowded chloritized mafic quartz plagioclase porphyry (QFP) has plagioclase (appx An₃₅) like that at 237; mafic mineral was an amphibole originally; quartz phenocrysts are subhedral - this may be Quintana's type 1a -; 434 - yellowish pervasively altered rock, possibly plagioclase porphyry, altered to carbonate, kaolinite, quartz and hydromica and cut by veins in the following sequence, early quartz (Q) - carbonate (C) - pyrite (P) - hematite cut by Q-C-P then C - kaolinite and finally C, disseminated hematite after magnetite, age of vuggy quartz-chalcopyrite vein uncertain but it is cut by Q and C veins; 522 - mafic (remnants of secondary biotite, mostly chlorite + carbonate + opaque now) plagioclase porphyry, matrix quartzofeldspathic with 20% carbonate and some sericite alteration, accessory minerals are opaque, apatite and zircon; 597 - bleached gray plagioclase porphyry (plagioclase yellow-white), plagioclase altered 90% to carbonate, sericite and quartz, matrix 10% altered to carbonate and sericite, vein sequences are Q-chlorite-C-magnetite-albite cuts Q-C and Q-C-sulphide which is cut by Q-some sericite-sulphide with flakey sericite alteration envelopes, gypsum veins cut all the others, age of Q-chalcopyrite veins uncertain, magnetite partly hematized.

Further comments (hand specimens): 300 - post-mineral hornblende (chlorite now) plagioclase porphyry; 169 - sericitized plagioclase porphyry with mafics altered to sericite and matrix is olive green, complex plagioclase zoning visible.

4. Hole Q73-12: The country rock varies from plagioclase porphyritic biotite altered rock (hornfels in my report) to spotted biotite altered rock. Biotite is invariably partly altered to sericite and generally also to carbonate chlorite and sometimes quartz; alteration intensity decreased down the hole.

Thin Sections: 240 - green-gray biotitized plagioclase porphyry of volcanic origin with sericite alteration adjacent to fractures, plagioclase 60% altered to sericite biotite and carbonate, biotite is brown or locally green and fine grained, matrix 70% altered to biotite sericite and carbonate, some secondary quartz, disseminated magnetite, pyrite and chalcopyrite; 302 - (hand specimen) - spotted "hornfels" with biotite- or chlorite-rich spots, matrix speckled with chlorite; 503 - biotitized plagioclase porphyry, plagioclase glomeroporphyritic complexly zoned, 40% altered to carbonate and sericite, matrix feldspathic, 20% altered, clumps of biotite (brown to green-brown)-carbonate-quartz-opaque, veins of quartz-chlorite-magnetite-chalcopyrite and gypsum (young).

5. Hole Q73-10: The hole is in fine grained to plagioclase porphyritic volcanic rock that is cut by QFP, mafic QFP and plagioclase porphyry dikes. The country rock had early pervasive biotite alteration that is now variably altered to chlorite and carbonate. Feldspars are altered to sericite carbonate quartz and some hydro-mica, mafics are chloritized. The QFP dikes seem to follow most of the biotite alteration but are affected by propyl-argillic alteration.

Thin Sections: 125 - tan, altered rock (derived from plagioclase porphyry?) cut by quartz-magnetite (partly hematized) -chalcopyrite veins that are cut by carbonate with pyritic halos cut by rusty carbonate veins; quartz is disseminated in the matrix and occurs as clumps of crystals (secondary), the matrix is also altered to sericite carbonate ; 205 - QFP, plagioclase 100% altered to sericite carbonate quartz; matrix to sericite carbonate quartz and hydro-mica, quartz veins have pyrite, chalcopyrite and bornite in central zones; 276 - partly chloritized biotitized plagioclase porphyry, alteration to biotite quartz, carbonate and some kaolinite(?), chlorite is largely after biotite, veins are quartz-carbonate-apatite and quartz-chlorite with or without biotite and magnetite, several percent disseminated magnetite; 380 - altered spotted "hornfels" - the matrix is altered to chlorite (some green biotite?) sericite and carbonate. The "spots" are pyrite, some chalcopyrite(?), sericite chlorite with coarser halos of chlorite sericite quartz and apatite; veins are sericite-quartz-chloritized biotite carbonate and pyrite, carbonate with some quartz, and carbonate-pyrite-chalcopyrite; 399 - QFP cut by yellowish carbonate veins, minor disseminated pyrite; looking at it now (1981) it looks layered and could be crystal ash tuff or is flow layered, plagioclase crystals are half altered to carbonate chlorite and kaolinite(?) with minor sericite, the matrix is 60% carbonate sericite chlorite altered, pods of carbonate with local quartz and pyrite are disseminated through the rock; 440 - spotted finely feldspathic rock, matrix half altered to dense, very fine carbonate, the rest is apparently a fine mosaic of quartz, the spots are pyrite apatite chlorite sericite and carbonate, veins are carbonate pyrite \pm quartz \pm chalcopyrite, quartz-

chlorite \pm sulphides, and gypsum; 574 - dark gray-green mafic(?) plagioclase porphyry dike, relatively crowded (plag. 30%, to 5 mm), plagioclase variably sericite and carbonate altered, matrix has fine plagioclase laths, half altered to carbonate and chlorite; 608 - mottled biotitized "hornfels", darker areas are largely fine biotite, "mottles" are biotite quartz sericitized feldspar and chlorite, several percent disseminate magnetite, veins of carbonate-gypsum cut the recrystallized biotite-quartz "mottles"; 842 - mottled dark gray and gray-white very fine grained rock cut by quartz-chalcopryrite veins, is a mosaic of finer and coarser zones of biotite-quartz-plagioclase (dusted by clay and carbonate alteration), quartz-feldspar (albite or k feldspar?) veins cut by gypsum-quartz-carbonate with some sericite, also quartz-feldspar-chlorite-carbonate veins; 912 - relatively crowded gray-green mafic QFP - plagioclase 40% to 5 mm, glomeroporphyritic, the complexly zoned plagioclase is 20% altered to carbonate quartz sericite and kaolinite(?), the matrix is also about 20% altered but to quartz, biotite (partly chloritized) sericite and carbonate, biotite occurs as clumps of brown crystals, some have replaced pyroxene, about 2% disseminated magnetite, veins of magnetite-sulphide-quartz-carbonate; 1228 - tan colored QFP, plagioclase altered 90% to sericite carbonate and quartz, mafic to carbonate, hydromica and sericite, matrix to sericite quartz and carbonate, there are crystalline quartz-sericite clumps and calcite-filled vugs, minor amounts of pyrite; 1241 - tan colored QFP, plagioclase yellow-white dust alteration to carbonate sericite and kaolinite (100%), mafics to hydromica quartz Fe-rich carbonate and opaques, matrix to carbonate, some hydromica and chlorite(?), veins of quartz-carbonate-pyrite-chalcopryrite are cut by carbonate veins; hand specimen from 493 there is a contact between plagioclase porphyry (dike) and a very fine grained volcanic rock, no chilling is evident, veins are quartz-magnetite \pm chlorite.

6. Hole Q73-15: The hole is in mafic plagioclase porphyry that gives way to an area dominated by QFP after about 400 feet. In most of the hole plagioclase is partly altered to sericite carbonate and quartz with local hydromica pyrite and kaolinite, mafics to chlorite \pm sericite \pm sulphides \pm magnetite - Fe carbonate and hydromica, secondary biotite was seen in only one thin section. Alteration averages 50% through the hole.

Thin Sections: 120 - fine grained crowded plagioclase porphyry, with mottled, chloritic matrix, plagioclase, average An_{40} , has complex oscillatory zoning and is 60% altered to sericite and carbonate, the matrix is biotitized and silicified with later sericite and chlorite alteration, 90% altered biotite-chlorite-opaque (magnetite) zones are probably pseudomorphous after mafics, disseminated magnetite and pyrite; 180 - fairly well mineralized altered crowded mafic plagioclase (An_{40}) porphyry, 1-2 mm plagioclase phenocrysts are altered to a cream-color but remnant complex zoning is visible, alteration products are carbonate and kaolinite with some chlorite and sericite, mafics altered to sericite chlorite apatite (may be inclusions) and sulphide, matrix half altered to chlorite sericite and carbonate, veins of carbonate (siderite?) kaolinite, and quartz with flakey sericite-rich envelopes; 310 - sulphide-rich tan altered rock, original textures destroyed, alteration is to carbonate sericite

quartz (in clumps) what were plagioclase crystals are now largely kaolinite with carbonate and sericite, veins of carbonate-quartz cut quartz veins that cut quartz-molybdenite-pyrite veins; 390 - pervasive cream to orangy alteration of plagioclase porphyry cut by quartz-pyrite veins with gray sericitic halos, alteration is 90% to sericite carbonate and quartz, quartz veins cut by carbonate-quartz veins; 440 - gray-green altered plagioclase porphyry, plagioclase complexly zoned, average An_{32} , variably altered to sericite and carbonate, mafics altered to chlorite sericite and Fe carbonate and opaques, matrix 60% altered to carbonate and chlorite, chloritic patches have pyrite and magnetite, vuggy veins of quartz-pyrite-apatite-carbonate-chlorite; 49.3 or 493(?) - altered QFP, plagioclase is a yellow-white color and is 90% altered to carbonate and kaolinite, quartz phenocrysts are partly intergrown with the matrix, the matrix is completely altered to carbonate and quartz, mafic minerals are altered to hydromica and Fe carbonate, veins are quartz, there are clots of quartz-chalcopyrite-hydromica, fractures are covered by quartz-chalcopyrite, primary magnetite is hematized.

7. Hole Q74-4: The volcanic country rock in the hole is mafic plagioclase porphyry or plagioclase porphyry that is cut by QFP dikes, one section of QFP is in excess of 100 feet thick and could be a sill (not sure because orientation of QFP zone not known), the QFP matrix is less altered than that of the country rock (except near contacts), the dominant alteration products are carbonate quartz and sericite with or without chlorite and kaolinite and local biotite, mafics alter to chlorite with or without sericite, quartz, carbonate, magnetite, pyrite, apatite and local biotite.

Thin Sections: 81 - gray mafic andesine (An_{43}) porphyry, plagioclase with carbonate and some chlorite alteration and has complex oscillatory zoning, disseminate magnetite and pyrite, veins are chlorite-quartz-pyrite-carbonate \pm sphene(?); 122 - bleached white plagioclase porphyry, pyritic, phenocrysts difficult to see in thin section due to alteration that is mainly carbonate, matrix extensively altered to carbonate and quartz, sheafs of gray birefringent white mica - overall alteration is argillic; 142 - gray plagioclase (An_{37} 2-3 mm, 40%) porphyry, alteration like 122 but less intense, mafics altered to chlorite and Fe-carbonate, pockets of carbonate-chlorite, vuggy veins of pyrite-quartz-sericite (flakey); 155 - dark gray green, slightly porphyritic altered volcanic rock, plagioclase complexly zoned, An_{40} to An_{20} , chlorite often forms "knots" or "pockets", alteration of the matrix is to chlorite carbonate and quartz, disseminated pyrite; 200 - gray green somewhat porphyritic volcanic rock, plagioclase 80% altered to carbonate with some sericite, the matrix has chlorite and quartz alteration, some sericite and pyrite-quartz-sericite-chlorite-apatite "knots"; 268 - altered crowded mafic plagioclase porphyry has similar alteration to that at 200, pyritic, pyrite associated with chlorite-apatite \pm sericite \pm carbonate \pm quartz, veins of pyrite-chlorite-carbonate; 288 - bleached, veins, flakey sericite in pockets, rock was plagioclase porphyry, plagioclase crystal outlines still visible but 90% altered to carbonate and sericite, matrix silicified and carbonate altered (80%), pyrite veins have quartz flakey sericite carbonate envelopes, apatite is an alteration product and is

associated with quartz, sericite and carbonate, veins carbonate seemingly cut by quartz-sericite \pm sulphides, that are cut by later carbonate, pyrite disseminated and in veins; 323 - altered gray crowded mafic plagioclase porphyry, plagioclase, average An_{43} , with oscillatory zoning, 10 to 25% altered to chlorite carbonate, matrix 95% altered to quartz chlorite and carbonate, veins quartz \pm sulphide, quartz-chlorite-sericite, abundant disseminated magnetite (4%); 370 - QFP, matrix looks aphanitic, pinkish color, plagioclase crystals 30% to 5 mm, altered to carbonate sericite and fine grained mineral(s) - possibly clay - alteration 98%, matrix is 15% altered to sericite and carbonate, clumps of quartz-pyrite-sericite-carbonate-apatite, carbonate veinlets; 496 - strongly altered QFP, plagioclase 100% altered to carbonate sericite and some quartz, quartz phenocrysts are rounded with minor overgrowths, mafics chloritized, matrix 90% altered to carbonate sericite quartz and chlorite, pyrite disseminated and in quartz veinlets, 7%; 516 - altered gray crowded mafic plagioclase porphyry, plagioclase 1-2 mm, 50%, cores altered to sericite and carbonate, twins still visible, An_{37} average, matrix completely altered to carbonate quartz sericite chlorite and biotite, pyrite in ragged clumps with quartz sericite chlorite carbonate halos, veins are pyrite-quartz-sericite-chlorite; 577 - altered plagioclase porphyry with 10% disseminated and vein pyrite, alteration nearly 100% to carbonate and quartz, veins are pyrite quartz sericite and carbonate; 625 - altered gray to cream colored crowded QFP, plagioclase 50%, 1-2 mm, plagioclase altered 100% to carbonate sericite and kaolinite(?), matrix 30% to carbonate and sericite, veins are quartz-pyrite-chalcopyrite, quartz-carbonate-sericite-pyrite-Fe carbonate-apatite, carbonate veinlets cut sericite fractures; 716 - veined plagioclase porphyry, plagioclase and matrix 60% altered to carbonate and sericite, dark gray pyrite (some quartz) veins with quartz-sericite envelopes are cut by gypsum carbonate veins; 765 - mottled, altered volcanic rock (mafic plagioclase porphyry), plagioclase with complex oscillatory zoning, An_{35} to An_{45} , 20% altered to carbonate and chlorite, matrix 50% altered to greenish brown biotite chlorite carbonate and some sericite, clumps of chlorite biotite magnetite pyrite apatite and carbonate occur; 800 - fairly crowded mafic plagioclase porphyry, plagioclase white, 1-2 mm, 35% in green chloritic matrix, plagioclase 98% altered to carbonate sericite quartz and kaolinite, mafics altered to chlorite pyrite and sericite, matrix 50% to sericite carbonate and chlorite, veins are quartz-chlorite-apatite-magnetite-pyrite.